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A Survey on Web Mining: Overview, Techniques, Tools, and Applications

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Abstract- Web Mining is moving the World Wide Web towards a more useful environment in which users can quickly and easily find the information they need. It uses document content, hyperlink structure, and usage statistics to assist users in meeting their needed information. Web mining is used to automatically discover and extract information from Web-related data sources such as documents, log, services, and user profiles. Although standard data mining methods may be applied for mining on the Web, many specific algorithms need to be developed and applied for various purposes of Web based information processing in multiple Web resources, effectively and efficiently. The term Web mining has been used in two distinct ways. The first, called Web content mining is the process of information discovery from sources across the World Wide Web. The second, called Web usage mining, is the process of mining for user browsing and access patterns. In this paper, we are trying to give a brief idea regarding web mining concerned with its techniques, tools, applications, and future directions.

Keywords: Web mining, Web Content Mining, Web Usage Mining, Web Structure Mining

I. INTRODUCTION

The Web may be defined as the universal, all-encompassing space containing all Internet resources. Basic idea of web mining is to assist users or site owners in finding something useful/interesting/relevant information. Web mining has two views in general. Web mining with the User-centric view allows to Discovery of documents on a subject, Discovery of semantically related documents or document segments, Extraction of relevant knowledge about a subject from multiple sources, Knowledge/information filtering. Web mining with the owner-centric view allows getting Increasing contact / conversion efficiency (Web marketing), Targeted promotion of goods, services, products, ads; Measuring effectiveness of site content / structure, Providing dynamic personalized services or content. In the field of Customer analysis, it includes customer profitability, modelling customer behaviour and reactions, customer satisfaction etc. Web mining in this field helps us to find strategy that should be used to get number of customers with quality as discussed in [2]. It is used to understand customer behaviour, evaluate the effectiveness of a particular Web site, and help quantify the success of a marketing campaign [1, 5].

Web mining is a new technology that has emerged as a popular area in the field of WI (Web Intelligence). Currently Web mining could be viewed as the use of data mining techniques to automatically retrieve, extract, generalize, and analyze information. It is obvious that data mining techniques ([1] [3] [4]) can be used for Web mining. Web mining, however, is very different from data mining in that the former is based on Web-related data sources, such as semi-structured documents (HTML, or XML), log, services, and user profiles, and the latter is based on more standard databases. The most critical problem with Web mining is the poor interpretability of mining results (e.g., the model of user profiles) since most of them are approximate concepts. Acquiring correct models of user profiles is difficult, since users may be unsure of their interests and may not wish to invest a great deal of effort in creating such a profile. Another difficult problem in WI Web Intelligence [9] is about filtering algorithms which are related to the efficiency of Web mining models. In traditional applications of AI Artificial intelligence, one of the main tasks is to construct Knowledge Bases (KB) for searching and reasoning. In Web-based intelligent information systems, however, the new feature is that the set of inputs is very large. To avoid searching all inputs in KBs, the challenging issue is to quickly discard most non-relevant inputs. There are three general classes of information that can be discovered by web mining [13]:

Web activity, from server logs and Web browser activity tracking.

Web graph, from links between pages, people and other data.

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Web content, for the data found on Web pages and inside of documents.

II. WHERE DID WEB DATA MINING COME FROM? [7]

Web data mining has grown out of the large volumes of data freely available on the web. Prior to data mining becoming a stand-alone task, business analysts and statisticians extracted and analyzed datasets. However, the large volume and technical nature of data necessitated the creation of data mining tools designed specifically for web data mining.

III. HOW WILL WEB DATA MINING BENEFIT MY BUSINESS? [8]

If you would like to know more about your customers and when and how they make purchases, web data mining could help. What differentiates business site visitors who read articles and move on to the next site, from site visitors who purchase your goods and services? You can search the traffic data on your company web site, or compiled in your database to find out when a person makes a purchase. Where did they come from and what pages of your site were of interest to them? These are some of the things you can mine from your data. Web data mining can also be used to extract data from elsewhere in your industry, such as price lists and user data.

Once web information is collected it can be used to improve your marketing results. Your company can make educated decisions about what kind of contacts to make with a customer, when, and in what format. Rules can be created about what type of data to gather, how it is organized, and how it is assessed. You can decide if it is most likely that a customer will make a purchase after he is contacted by email, or snail mail or phone based on the information that you have mined.

IV. CHARACTERISTICS OF WEB DATA

Following are some of the characteristics of web data that makes it hard to mine:

Information on the Web is mainly in heterogeneous form. Due to the diverse authorship of Web pages, multiple pages may present the same or similar information using completely different words and/or formats. This makes integration of information from multiple pages a more challenging task.

There is a significant amount of information present on the Web is linked. Hyperlinks exist among Web pages within a site and across different sites. Within a site, hyperlinks serve as information organization mechanisms but when it is present across different sites, it represents implicit conveyance of authority to the target pages. That represent, those pages that are linked or pointed to by many other pages are usually high quality pages or authoritative pages simply because many people trust them.

The information on the Web is noisy. This noise comes from two main sources. First, a typical Web page contains many pieces of information, e.g., the main content of the page, navigation links, advertisements, copyright notices, privacy policies, etc. But for a particular application, only part of the information is useful. The rest is considered as a noise. To perform fine-grain Web information analysis and data mining, the noise should have to be removed. Second, because the Web does not have quality control of information, i.e., one can write almost anything that one likes, a large amount of information on the Web is of low quality, erroneous, or even misleading.

The Web also provides services. Most commercial Web sites allow people to perform useful operations at their sites, e.g., to purchase products, to pay bills, and to fill in forms, by which important personal information is going from one place to another on the web.

The Web is dynamic, as the information on the Web changes constantly. Keeping up with the change and monitoring the change are important issues for many applications.

V. WEB MINING VERSUS DATA MINING[7]

When comparing web mining with traditional data mining, there are three main differences to consider:

A. Scale

In traditional data mining, processing 1 million records from a database would be a large job. In web mining, even 10 million pages wouldn't be a big number.

B. Access

When doing data mining of corporate information, the data is private and often requires access rights to read. For web mining, the

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data is public and rarely requires access rights. But web mining has additional constraints, due to the implicit agreement with webmasters regarding automated (non-user) access to this data. This implicit agreement is that a webmaster allows crawlers access to useful data on the website, and in return the crawler (a) promises not to overload the site, and (b) has the potential to drive more traffic to the website once the search index is published. With web mining, there often is no such index, which means the crawler has to be extra careful/polite during the crawling process, to avoid causing any problems for the webmaster.

C. Structure

A traditional data mining task gets information from a database, which provides some level of explicit structure. A typical web mining task is processing unstructured or semi-structured data from web pages. Even when the underlying information for web pages comes from a database, this often is obscured by HTML markup.

VI. WEB LOG STRUCTURE[6]

There are several kinds of log format. Most common format: Common Log Format (CLF) Common Log Format (www.webdeveloper.com). The common log format appears exactly as follows:

```
host/ip rfcname logname [DD/MMM/YYYY:HH:MM:SS -0000]  
"METHOD /PATH HTTP/1.0" code bytes
```

host/ip	If reverse DNS works and DNS lookup is enabled, the hostname of the client is dropped in; otherwise the IP number displays.
RFC name	You can retrieve a name from the remote server for the user. If no value is present, a "-" is substituted.
logname	If you're using local authentication and registration, the user's log name will appear; likewise, if no value is present, a "-" is substituted.
timestamp	The format is day, month (three-letter abbreviation), year, hour in 24-hour clock, minute, second, and the offset from Greenwich Mean Time (for example, Pacific Standard Time is -0800).
retrieval	Method is GET, PUT, POST, or HEAD; path is the path and file retrieved; HTTP/1.0 defines the protocol.
Code	HTTP completion code. 200 is successful, 304 is a reload from cache, 404 is file not found, and so forth.
Bytes	Number of bytes in file retrieved.

Table 1: Web log terms

Here's an example:

```
sniksnak.foo.bar.org--[30/Feb/1996:06:03:24 -0800]  
"GET /film/logos/the.movies.main.gif HTTP/1.0" 200 278
```

VII. PROBLEMS WITH WEB LOG

As discussed in [6] there are several problems in web logs. We discuss some of them below in short.

A. Identifying Users

Clients may have multiple streams and they may access web from multiple hosts, Proxy servers where many clients/one address and one client with many addresses.

B. Data Not In Log

POST data (i.e., CGI request) not recorded, Cookie data stored elsewhere.

C. Missing Data

Pages may be cached sometimes, Referring page requires client cooperation, When does a session end, also matters. Make use of forward and backward pointers.

D. Web Content May Be Dynamic

Sometimes it may not be able to reconstruct what the user saw.

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E. Use of Spiders And Automated Agents
Automatic request web pages

VIII. WEB MINING TAXONOMY[6]

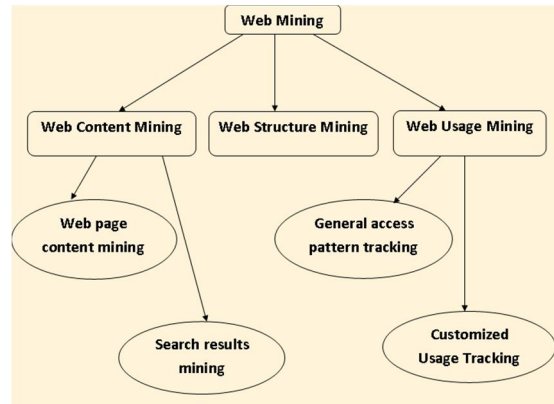


Fig 1: Web mining taxonomy

Below we describe a Figure 1 term in short

Firstly, Web Content Mining deals with Web Page Content Mining and Summarization of Web page contents (WebSQL, WebOQL, WebML, WebLog, W3QL). Secondly, Web Structure Mining deals with Search Result Mining, Summarization of search engine results (PageRankTM), Capturing Web's structure using link interconnections (HITS). And finally, Web Usage Mining deals with General Access Pattern Mining which in turn Uses KDD techniques to understand general user patterns (WUM, WEBMiner, WAP, WebLogMiner), and also deals with Customized Usage Tracking which in turn observes adaptive sites.

A. Web Structure Mining

The process of discovering structures information from the web documents are called as web structure mining. This mining can be performed either document level or hyperlink level. The hyperlinks provide clear navigation and point to the pages. This is used to retrieve the useful information in the form of structure. Hyperlink analysis can be done based on knowledge models, scope and properties of analysis and types of algorithms. The methods that are done in the web usage mining are Data cleaning, Transaction identification, Data integration, Transformation, Pattern Discovery, Pattern Analysis [11].

B. Web Content Mining

Web content mining data may be structured or unstructured/semi structured even though such of web is unstructured. It is the process of retrieving the information from the web into more structured forms and indexing the information to retrieve quickly or finding valuable information from web content or web documents. Web content mining includes the web documents which may consist of text, html, multimedia documents i.e., images, audio, video and sound etc. The search result mining contains the web search results. It may be a structure documents or unstructured documents [10].

C. Web Usage Mining

Web usage mining is used to discover the interesting usage patterns form the usage data. This includes server data (IP address), Application server data (web logic), and Application level data (events). This is otherwise a Discovery of meaningful patterns from data generated by client-server transactions on one or more Web localities. The source database is access logs, referrer logs, agent logs, and client-side cookies [12].

D. Web Log Analysis Tools

As in [6], We have several tools to analyse web logs so that it will be easy to track what actually customer is interested in. Here we discuss some of them

We analyse Frequently used, pre-defined reports such as, Summary report of hits and bytes transferred, List of top requested URLs,

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List of top referrers, List of most common browsers, Hits per hour/day/week/month reports, Hits per Internet domain, Error report, etc.

Tools are limited in their performance, and depth of analysis. For Example: WebTrends, Analog.

E. Data Preparation [9]

Before giving data to any processing logic it is necessary to prepare data according to input prototype with respect to processing logic. Necessary steps to be taken while preparing data.

Firstly, Data cleaning where in you need to Remove irrelevant references and fields in server logs, Remove references due to spider navigation, Remove erroneous references. Secondly, Data integration where in you need to Synchronize data from multiple server logs, Integrate e-commerce and application server data, Integrate meta-data, content and structure data, Integrate demographic / registration data. Thirdly, Data Transformation where in you have to do Pageview identification, User identification, Sessionization / episode identification. Finally, Data Reduction where in you perform Sampling; dimensionality reduction (ignoring certain pageviews / items).

IX. WEB MINING TOOLS

In today's technological world we have lots and lots of tools designed to track customers' point of view. Similarly we have tools for web mining for getting better and better results [7]. Following are some of the widely used tools:

AlterWind Log Analyzer Lite, quickly generates all traditional reports, supporting 430+ search engines from 120 different countries. Analog (from Dr. Stephen Turner), a free and fast program to analyse the web server logfiles (Win, Unix, more)

jwanalytics, a Java utility for the storage of information in a dimensional model, useful for storing Web Analytics data for Java web applications; Web real time data mining functionality being built.

htminer, support analysis of web logs (including unique visitors, sessions, transactions); organises the data in a PostgreSQL data warehouse.

Visitorator, Clustering and visual presentation of visitor groups based on access patterns.

WUM: Web Utilization Miner, an integrated, Java-based Web mining environment for log file preparation, basic reporting, discovery of sequential patterns and visualization.

X. WEB MINING RESEARCH ISSUES

The web is highly dynamic; lots of pages are added, updated and removed everyday and it handles huge set of information hence there is an arrival of many number of problems or issues. Normally, web data is high dimensional, limited query interface, keyword oriented search and limited customization to individual users. Due to this, it is very difficult to find the relevant information from the web which may create new issues. Web mining techniques are classification, clustering and association rules which are used to understand the customer behaviour, evaluate a particular website by using traditional data mining parameters. Web mining process is divided into four steps; they are resource finding, data selection and pre-processing, generalization and analysis [16] [17]. Web measurement or web analytics are one of the significant challenges in web mining. The measurement factors are hits, page views, visits or user sessions and find the unique visitor regularly used to measure the user impact of various proposed changes. Large institutions and organizations archive usage data from the web sites [18]. The main problem is that, detecting and/or preventing fraud activities. The web usage mining algorithms are more efficient and accurate. But there is a challenge that has to be taken into consideration. Web cleaning is the most important process but data cleaning becomes difficult when it comes to heterogeneous data [14]. Maintaining accuracy in classifying the data needs to be concentrated. Although many classification techniques exist the quality of clustering is still a question to be answered.

A. Major Issues in Web Mining

Web data sets can be very large, it takes ten to hundreds of terabytes to store on the database

It cannot mine on a single server so it needs large number of server

Proper organization of hardware and software to mine multi-terabyte data sets

Limited customization, limited coverage, and limited query interface to individual users

Automated data cleaning

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Over fitting and under fitting of data
Over sampling of data
Scaling up for high dimensional data
Mining sequence and time series data
Difficulty in finding relevant information
Extracting new knowledge from the web

XI. WEB MINING APPLICATIONS

Past few years has led to the web applications being developed at a much faster rate in the industry than research in web related technologies. Many of these are based on the use of web mining concepts, even though the organizations that developed these applications.

A. Web Search--Google

Google is one of the most popular and widely used search engines. It provides users access to information from over 2 billion web pages that it has indexed on its server. The quality and quickness of the search facility makes it the most successful search engine. Earlier search engines concentrated on web content alone to return the relevant pages to a query. Google was the first to introduce the importance of the link structure in mining information from the web. PageRank, which measures the importance of a page, is the underlying technology in all Google search products, and uses structural information of the web graph to return high quality results. The Google toolbar is another service provided by Google that seeks to make search easier and informative by providing additional features such as highlighting the query words on the returned web pages. Google's web directory provides a fast and easy way to search within a certain topic or related topics. The advertising program introduced by Google targets users by providing advertisements that are relevant to a search query. One of the latest services offered by Google is Google News. It integrates news from the online versions of all newspapers and organizes them categorically to make it easier for users to read "the most relevant news." It seeks to provide latest information by constantly retrieving pages from news site worldwide that are being updated on a regular basis.

B. Web-Wide Tracking

"Web-wide tracking," is an individual across all sites he visits, is an intriguing and controversial technology. It can provide an understanding of an individual's lifestyle and habits to a level that is unprecedented, which is clearly of tremendous interest to marketers. Example- DoubleClick Inc.

C. Understanding Web Communities-AOL

It is One of the biggest successes of America Online (AOL) has been its sizeable and loyal customer base. A large portion of this customer base participates in various AOL communities, which are collections of users with similar interests. AOL provides them with useful information and services. Over time these communities have grown to be well-visited waterholes for AOL users with shared interests. Applying web mining to the data collected from community interactions provides AOL with a very good understanding of its communities, which it has used for targeted marketing through advertisements and e-mail solicitation. Recently, it has started the concept of "community sponsorship," whereby an organization, say Nike, may sponsor a community called "Young Athletic Twenty Somethings."

D. EBay

The genius of eBay's founders was to create an infrastructure that gave this urge a global reach, with the convenience of doing it from one's home PC. E-bay has detailed data on bid history, participant rating, bid data, usage data. In addition, it popularized auctions as a product selling and buying mechanism and provides the thrill of gambling without the trouble of having to go to Las Vegas. All of this has made eBay as one of the most successful businesses of the internet era. eBay is now using web mining techniques to analyze bidding behaviour to determine if a bid is fraudulent .Recent efforts are geared towards understanding participants' bidding behaviours/patterns to create a more efficient auction market.

E. Personalized Portal for the Web—MyYahoo

Yahoo is an one of the search engine. Yahoo was the first to introduce the concept of a "personalized portal," i.e. a web site designed

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to have the look-and-feel and content personalized to the needs of an individual end-user. Mining MyYahoo usage logs provides Yahoo valuable insight into an individual's web usage habits, enabling Yahoo to provide personalized content, which in turn has led to the tremendous popularity of the Yahoo web site.

F. V-TAG Web Mining Server-Cannotate Technologies

The web mining server supports information agents that monitor, extract and summarize information from web sources. It is easily to set up graphical user interface. Automation of tracking and summarizing helps businesses and enterprises to analyse the various processes easily

XII. WEB MINING PROS AND CONS

A. Pros

Web usage mining essentially has many advantages which makes this technology attractive to corporations including the government agencies. This technology has enabled e-commerce to do personalized marketing, which eventually results in higher trade volume.

B. Cons

This technology when used on data of personal nature might cause concerns. The most criticized ethical issue involving web usage mining is the invasion of privacy. Privacy is considered lost when information concerning an individual is obtained, used, or disseminated, especially if this occurs without their knowledge or consent.

XIII. FUTURE WORKS

Web and its usage grows, it will continue to generate ever more content, structure, and usage data, and the value of web mining will keep increasing. To develop a web mining technologies that will enable this value to be realized.

A. Process Mining

Mining of market basket data, collected at the point-of-sale in any store, has been one of the visible successes of data mining. However, this data provides only the end result of the process, and that too decisions that ended up in product purchase. Click-stream data provides the opportunity for a detailed look at the decision making process itself, and knowledge extracted from it can be used for optimizing, influencing the process, etc. It has conclusively proven the value of process information in understanding users' behaviour in traditional shops. Research needs to be carried out in (1) extracting process models from usage data, (2) understanding how different parts of the process model impact various web metrics of interest, and (3) how the process models change in response to various changes that are made, i.e. changing stimuli to the user. Example-online shopping.

B. Web Mining And Privacy

There are many benefits to be gained from web mining; a clear drawback is the potential for severe violations of privacy. Public attitude towards privacy seems to be almost schizophrenic, i.e. people say one thing and do quite the opposite. For example, famous cases like those involving Amazon and Doubleclick seem to indicate that people value their privacy, while experience at major e-commerce portals shows that over 97% of all people accept cookies with no problems, and most of them actually like the personalization features that are provided based on it. The research issue generated by this attitude is the need to develop approaches, methodologies and tools that can be used to verify and validate that a web service is indeed using user's information in a manner consistent with its stated policies.

C. Fraud And Threat Analysis

The anonymity provided by the web has led to a significant increase in attempted fraud, from unauthorized use of individual credit cards to hacking into credit card databases for blackmail purposes. Example is auction fraud, which has been increasing on popular sites like eBay. Since all these frauds are being perpetrated through the internet, web mining is the perfect analysis technique for detecting and preventing them. Research issues include developing techniques to recognize known frauds, characterize them and recognize emerging frauds. The issues in cyber threat analysis and intrusion detection are quite similar in nature.

D. Web Services Performance Optimization

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These services over the web continues to grow, there will be a continuing need to make them robust, scalable and efficient. Web mining can be applied to better understand the behaviour of these services, and the knowledge extracted can be useful for various kinds of optimizations. The successful application of web mining for predictive prefetching of pages by a browser has been demonstrated. It is necessary to do analysis of the web logs for web services performance optimization. Research is needed in developing web mining techniques to improve various other aspects of web services.

XIV. CONCLUSION

In this paper we focus on web mining phases, pros and cons, issues, applications, research issues and tools. Web mining taxonomy deals with three phases of web mining in which there exist lots of techniques and issues for each phase. There are so many tools available to work on web mining some prominent tools are discussed in this paper. We also discussed some research issues and major issues which are faced by web mining and yet to be solved. Finally applications are discussed which specifies a fields where actually web mining is used.

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